1. PHD PROJECT DESCRIPTION

Project title: Biodegradable iron-based materials - studies on the relationship between the chemical structure and surface morphology of systems and their mechanical properties, susceptibility to corrosion and biological activity

1.1. Project goals: The scientific goal of the proposed project is to gain the comprehensive knowledge about the relationship between the structure and the morphology of new biodegradable nano- and microarchitectonic 3D iron-based systems, obtained in a simple replica method, with the use of reticulated sponges made of polyurethane as a template (which was mainly used so far for oxide materials synthesis), and their mechanical properties, wettability, corrosion susceptibility as well as biocompatibility and biological activity, including promoting erhytropoiesis, antithrombogenic and anti-inflammatory properties. The knowledge acquired in the field of basic research on iron-based systems can broaden the current knowledge about the properties of iron and systems based on it, and in the future it can serve as the foundation for application research aimed at using biodegradable iron-based systems to produce biomaterials for cardiovascular diseases therapy. However, for this to be possible, it is necessary to acquire a fundamental basic knowledge about the relationship between 3D iron and iron-based systems' chemistry and their biological properties.

1.2. Outline: The current stent technology is based on the use of permanent stent made from 316L stainless steel, nitinol and cobalt-chromium alloy, which are corrosion-resistant systems [1]. The implantation of bare metal stents has shown tremendous superior effects in various kinds of clinical situations, especially in the field of percutaneous coronary intervention, however they have specific drawbacks, which limit their more widespread use [2]. Since the major effect of stent implantation is provided by its scaffolding effect, it is required to last 6-12 months during which arterial remodeling and healing is achieved. After this period, the presence of stents within the body cannot provide any beneficial effects. Thus the development of biodegradable stents, which can fulfill the mission and step away, is the logical approach. A near two decades long investigations into bioabsorbable stent materials have included both polymeric and metallic materials [3]. Poly-L-lactic acid (PLLA) has been shown to possess acceptable biocompatibility, but a polymeric stent requires a greater strutthickness than most metal stents because of the polymer's lower ultimate tensile strength [4]. In the case of metals, their degradability is closely related to their susceptibility to corrosion. And although corrosion is generally considered as a failure in metallurgy, the corrodibility of certain metals can be an advantage for their application as degradable implants. The candidate metallic biodegradable materials for such application should have mechanical properties ideally close to those of 316L stainless steel, in order to provide mechanical support to diseased arteries. Non-toxicity of the metal itself and its degradation products is another requirement as blood and cells absorb the material. Based on the mentioned requirements, magnesium-based and iron-based alloys have been investigated as candidates for biodegradable stents [5-8]. Within the proposed project it is planned to make studies on the synthesis of new pure iron and iron-based 3D materials of defined nano- or microarchitecture and analysis of the relationship between their structure and morphology and mechanical properties, the susceptibility on the corrosion in an environment of body fluids and blood, and the biological activity *in-vitro/in-vivo*. Such comprehensive studies of the proposed systems have not been conducted so far. Thus, it is possible to generate in the course of the project a new, important for contemporary biomedical engineering knowledge.

1.3. Work plan: The works planned for a period of four years are divided into seven research tasks: 1. Synthesis of iron-based material with defined nano / microarchitecture given by the template; 2. Enrichment of iron-based materials with other individuals of potential biological activity 3. Structural and morphological characteristics of obtained iron-based materials; 4. Analysis of physico-chemical properties, wettability and free surface energy of obtained iron-based materials; 5. Studies on the susceptibility of obtained iron-based materials to corrosion; 6. Analysis of mechanical properties of obtained iron-based materials; 7. Analysis of the obtained iron-based materials in terms of their biocompatibility biological activity, including promoting erhytropoiesis, antithrombogenic and anti-inflammatory properties one.

1.4. Literature:

[1] Emilio B., Lobato MD "Care of the Patient With Coronary Stents Undergoing Noncardiac Surgery", in *Essentials of Cardiac Anesthesia for Noncardiac Surgery*, Kaplan J.A. (ed.), 2019, Elsevier
[2] Bowen P.K., Shearier E.R. et al., *Advanced Healthcare Materials*, 2016, *5,* 1121-1140
[3] Waksman R., *Journal of Invasive Cardiology*, 2006, *18*, 70-74
[4] Bunger C.M., Grabow N., et al. *Journal of Endovascular Therapy*, 2007, *14,* 725-733
[5] Moravej M., Mantovani D., *International Journal of Molecular Sciences*, 2011, *12*, 4250-4270
[6] Gu X. N., Zheng Y.F., *Frontiers of Materials Science in China*, 2010, *4*, 111-115
[7] Peuster M., Wohlsein P., et al., *Heart*, 2001, *86*, 563-569
[8] Moravej M., Prima F., et al., *Acta Biomaterialia*, 2010, *93*, 1-11

1.5. Required initial knowledge and skills of the PhD candidate: Knowledge of basic methods of synthesis and analytical methods for conducting structural and morphological characteristics of materials. Willingness to increase the competence in the field of biomaterial chemistry. Very good command of English in writing and speaking, due to planned extensive scientific cooperation. Ability to work in a team. Possibility of being involved in an internship and several shorter study visits.

1.6. Expected development of the PhD candidate's knowledge and skills: The PhD student will acquire interdisciplinary knowledge in the field of modern biomaterials, material engineering, methods of instrumental analysis to characterize the structure, morphology, mechanical properties and basic knowledge in the field of in-vitro and in-vivo biological research. In addition, the doctoral student will gain experience in preparing conference presentations and publications.